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AGRICULTURAL COLLEGE AND EXPERIMENTAL FARM.

LUCERNE OR ALFALFA: COMPOSITION AND DIGESTIBILITY.

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INTRODUCTION.

In many parts of the Province of Ontario a great deal of interest is taken in the growing of lucerne. This is, at least partly to be accounted for by the fact that the plant grows and produces large crops even in our dryest weather. During the past extremely dry season, when most grasses were brown and parched, the lucerne was a rich green color, making a luxuriant growth. In the past, in many places, it has been grown only in small plots near farm buildings, to be used as a supplementary food for farm stock, especially for working horses. Now, on many hundred-acre farms, ten, fifteen, and even twenty acres of lucerne may be found, and many tons of hay are made from it every year. The idea seems to prevail that though this plant produces an immense amount of rich food when cut and used green, yet when cut and cured as hay, it forms a harsh, stalky, indigestible fodder. So, to ascertain what ground there is for this idea, and to learn, if possible, at what

Fig. 1. Single plant of lucerne, showing the large number of stems from one strong tap-root; also, an elongated underground stem bearing branch-producing stalks.

stage in its growth the plant should be cut to get the maximum amount of digestible constituents, the work of this bulletin was undertaken. While all the work has been done with scientific accuracy, the treatment of the subject in the bulletin is of a practical, rather than a scientific, character.

History of Plant.

Lucerne, or Alfalfa (*Medicago sativa*), is a plant of the large and valuable botanical family called Leguminosæ. The clovers all belong to this family and form a peculiar but interesting series of plants botanically and practically, as well as chemically. Lucerne, though not a true clover, resembles the clover very much; it belongs to the genus *Medicago*, while the clovers are of the genus *Trifolium*. Lucerne is one of the most ancient of forage plants, having been cultivated by the Greeks, Romans, and Egyptians before the Christian era, and at a later date especially within the nineteenth century, by many of the nations of Europe. The Spaniards introduced it into South America, where it has been grown for a long time, especially in the arid and semi-arid regions along the west shore. From this region it was introduced into Mexico and California; and from there it has spread across the western states and the territories of the United States, where it still retains the Spanish name of Alfalfa. The same plant coming to us from countries of Europe, other than Spain usually goes by the the name of Lucerne, from the valley of Lucerne in Switzerland, where it is grown in very large quantities.

Description of Plant.

Lucerne is rather a slender growing, branching perennial plant, with leaves much smaller than those of the common red or mammoth red clover. It is of a peculiar dark, rich green color which is easily distinguished in a dry season, even at a considerable distance. The lucerne blossoms differ markedly from those of the clovers, the latter having blossoms aggregated or clustered in a somewhat rounded head or bunch, while the former has its beautiful small, hooded, or pea-like, purple blossoms scattered along the stem loosely, in what the botanist calls a raceme. Again, the seed pods are single and coiled spirally, while in the red and white clovers they are straight and crowded into a head. The brownish yellow seeds resemble those of the red clover somewhat, but are larger, longer and more kidney-shaped.

The plant usually has a single long and strong tap root, which throws off numerous small branches or rootlets as it passes downwards. Various influences may cause an apparent breaking up of this tap root into a number of smaller roots, which, however, penetrate the soil almost as deeply as the main root. In an open, porous subsoil the tap-roots have been traced to a depth of twelve and fifteen feet. In such a soil the length of the root seems to be limited only by the distance to the water table, even if that be twenty or thirty feet below the surface. Good strong roots have been found at a depth of eight feet in very heavy clay soil. These roots on decaying leave little tube-like openings leading down into the ground in all directions, and must be of considerable value as a means of underdraining and aerating the soil. Again, these roots running so deeply into the soil are of great value in bringing back to the surface plant food which has been washed down beyond the

reach of other plants, and also in bringing the plant into contact with water that is largely unavailable for the growth of other crops.

In addition to this lucerne, like the clovers, has the power of assimilating the free nitrogen of the atmosphere. All members of the leguminosæ family, which includes peas, vetches, lupines, clovers and lucerne, are found to have small nodules or tubercles on their roots. These tubercles, knots, or nodules contain millions upon millions of extremely small vegetable organisms called bacteria, which live on the juices of the root and in the process of develop-

Fig. 2. Single stem of lucerne taken from plant shown in Fig. 1.

Fig. 3. Plants three months from date of seeding, showing the long tap-root and the small development of top as compared with the root.

ment supply the plant with an available form of nitrogen which they by some means, not as yet thoroughly understood, transform from the free nitrogen of the atmosphere. Thus, through the agency of these minute organisms, leguminous plants have at their disposal a practically unlimited supply of nitrogen, which, so far as is known, is unavailable to other farm crops. For this reason all the legumes are valuable as improvers of soil fertility. Lucerne is especially valuable, owing to its extraordinary length of root which brings it into contact with nitrates and ash constituents that are out of the reach of

other plants; and these must of necessity be carried up to the growing parts of the plant and thus become available for food or manure. This conclusion is fully borne out by the results of chemical analysis; for upon reference to tables of analysis, it will be seen that as a food for young and growing stock it is the equal of any of our fodders; and that in nitrogen, potash and phosphoric acid, it is richer than the grasses and fully as rich as the clovers.

Cultivation.

One drawback to the growing of lucerne is the fact that it cannot be used in a short rotation of crops. On account of the length of time it requires to become established in the soil, and on account of the size and toughness of the roots, the land seeded with lucerne should be selected with the view of allowing it to remain for a number of years. Just how long it may be profitably left before breaking up depends very much upon how clean the land was at the time of seeding; but the time varies between six and twelve years, although in some cases it has been found profitable to leave it even longer. A crop that is expected to hold the ground for so long a period, should have a faultless seed-bed. It will amply repay careful cleaning of the land previous to seeding. This is especially true on rather poor land, where the first year's crop will likely be small and consequently in danger of being oversome with weeds. The land may be prepared by means of a late summer fallow, or better, the seeding may follow a hoed crop; but, whatever the preparation of the land, it must be clean and, as the seeds are small, it is essential that it be in a very fine condition mechanically.

The soil best suited for the growth of lucerne seems to be a deep loam, rather dry, containing a fair proportion of lime, with *good deep natural drainage*. It will, however, do well upon almost any soil that is well drained, provided it once becomes well rooted. Heavy clay and light sandy soils both produce excellent crops of lucerne, but on the latter it naturally requires generous manuring. It should never be sown on land in which the water table stands near the surface, or on land likely to be covered with water at any season of the year. This will exclude most low-lying ground where grasses naturally do well.

The amount of seed sown varies considerably, some sowing about 15 lbs. of seed per acre, while others use as much as 40 lbs., or even more. Under ordinary conditions 15 to 20 lbs. per acre are sufficient. The covering may be done with a light harrow and roller. If sown with oats, barley, or the like, not more than about one half the ordinary amount of grain should be sown per acre, even then the young plants are apt to be killed by exposure to the sun when the "nurse" crop is removed, especially if hot dry weather follows the cutting of the grain crop. Better results are usually obtained by sowing the seed alone. The best time to sow is as soon as the ground can be got into good condition in the spring and danger of heavy frosts is passed. In some cases, difficulty is experienced in getting a good stand on clay soils. An excellent "catch" has been obtained over bare, heavy clay knolls by giving them a top dressing with barnyard manure at the time of seeding.

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FIG 4. This photograph represents the face of an opening made to the depth of rather more than 13 feet in an alfalfa field on the Experiment Station Farm, at Rocky Ford, Otero County, Colorado. The soil is a fine alluvium. The roots penetrated to a depth of 12 feet 6 inches, and the simplicity of the root system is well shown, the roots being shown in their natural position. The upper margin of the photograph represents the surface of the ground, which lacks sufficient sharpness to show the crowns and stubble in the picture.

This alfalfa was four years old and cut from four to five tons of hay a year. The diameter of these roots, just below the crown, averaged a little less than ½ inch.

Vitality of Seed.

A great deal has been written concerning the poor vitality of lucerne seed. North Carolina Bulletin No. 60 has the following: "The vitality of lucerne seed is so low that seed over one year old is scarcely worth sowing." London says: "Great care should be had to procure it (lucerne seed) plump and perfectly new, as two years old seed does not come up freely. Colorado Bulletin No. 35 records a germinating experiment in which a very high percentage of seed, two, three and six years old, sprouted. The United States Experiment Station Record, Vol. vi, No. 5, gives in tabular form the result of an eleven years' test of the duration of the vitality of some agricultural seeds made by S. Samek* from which the following is taken. Well matured seed was selected, a portion of which was examined each year from 1883 to 1894. The unused portions were kept in paper bags in a dry airy room and seeds taken from them each succeeding year for the test

Results of Eleven Years' Seed Testing.

Kinds of seed.	Percentage of vitality.										
	1 year	2 yrs.	3 yrs.	4 yrs.	5 yrs.	6 yrs.	7 yrs.	8 yrs.	9 yrs.	10 yrs.	11 yrs.
Lucerne	94	91	87	75	72	71	68	66	63	59	54
Red clover	90	90	88	84	74	68	44	16	10	3	2
Alsike	73	64	51	37	15	7	6	5	3	3	3
White clover	74	72	63	52	50	50	35	31	26	23	22
Timothy	95	90	90	88	86	79	66	39	15	1	0
Orchard grass	46	47	44	44	38	29	21	12	8	5	

It will be seen that in the first year of the experiment, out of 100 seeds of lucerne planted, 94 germinated; of the same number of red clover, 90 germinated; of alsike, 73; of white clover, 74; of timothy, 95; of orchard grass, 46; while in the eleventh year but 54 out of the 100 seeds of lucerne grew, 2 of red clover, 3 of alsike, 22 of white clover, and none of either timothy or orchard grass. According to these figures, age does not affect the vitality of lucerne seed so much as it does the other seeds used in the experiment. No observations, however, were made by the experimenter regarding the strength of the plants from the old seed as compared with those from the new seed.

Care of Crop.

The first year is the most critical period in the growth of lucerne; and, unless on very rich ground, no crop need be expected the first season. During that time the roots are pushing down deep into the soil, so that the plants may be in a position to grow a good top the second year. If there be considerable growth, the crop may be lightly pastured, but not late in the season.

* Tirol. landu. Blatter, 13 (1894), No. 18, pp. 161, 162, 1883 to 1894.

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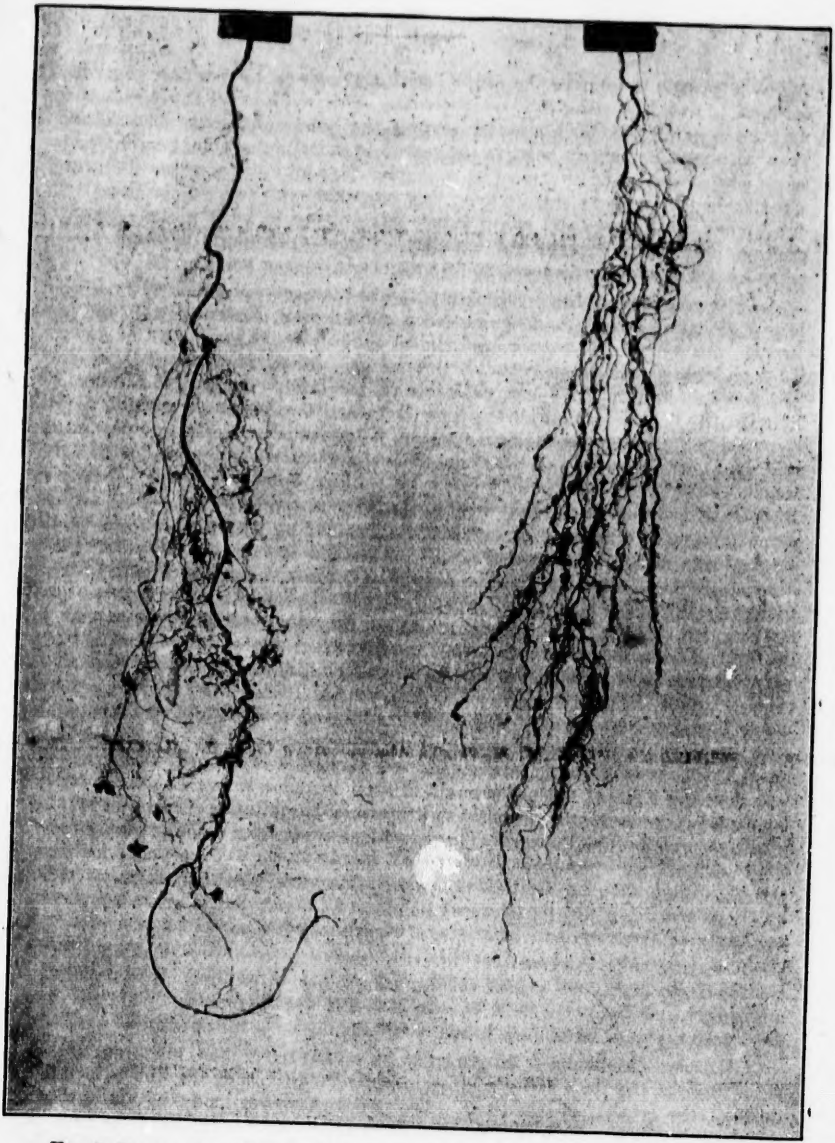

FIG. 5. It was not possible to get the details of the small roots in photographs of plants whose roots were from 7 to 11½ feet long. We present in this plate the terminal portions of two roots, 7½ feet from the surface, each showing nodules, which appear as round or irregular black spots on the roots. The extremities of the tap roots, I regret, were broken off.

A better plan is to go over the ground with the mower, having the finger-bar set high to avoid injuring the young plants. This will cut off any weeds that may be growing and form a mulch around the growing plants. The second year, although not at its best, if the season is at all favorable, two or three crops may be cut; and this may be continued for a number of years. During a particularly favorable season, even four crops may be secured. When it is cut for hay, an average soil will produce from fifteen to twenty tons of green crop per acre. The lucerne grown on the college experimental grounds yielded as an average of three years 20.33 tons of green crop per acre.

In some sections the first cutting for the season, which is always the largest, is cured as hay, and the second is cut for seed, after which it is pastured. By other farmers it is used almost entirely for pasture, but owing to some peculiarities of its growth it is not so well suited for pasturing as for use as a soiling crop. If lucerne is to be pastured, enough stock must be kept on the field to eat off all the growth before the plant passes the early blossoming stage, or else the field must be mown as often as the plants reach that stage of maturity. A more nutritious pasture will be obtained in this way. If the field be too closely pastured, the crop may be injured. Farmer's Bulletin No. 31 offers the following explanation on this point, "The young plant consists of a number of low branches springing up from a simple basal stalk at the crown of the root. The branches ascend directly above the ground and form a compact tuft. On the old plant, however, certain of the more robust stems elongate underground and become new branch-producing stalks. In this way the simple stalk, or rhizome, becomes two or many headed. When the stems are cut or grazed off, the stalk dies down to the very base and new buds spring up on the upper part or crown of the new root and grow, forming new stems. This method of growth explains why many farmers have reported that alfalfa is injured or destroyed by continuous close grazing. The stems of many other forage plants, when cut or broken, branch out above ground, forming lateral shoots that immediately grow up and take the place of the old stems. If alfalfa is closely grazed, and if every young stem is eaten off as rapidly as it appears, the vitality of the root will be impaired and the plant may die, because the new growth comes directly from the root itself, and not from the bases of the old stems. There is more danger of killing out the alfalfa fields when sheep are pastured on them than by the pasturing of cattle, horses or hogs, as the latter do not graze the plants as closely as do sheep, except at times when there is insufficient forage."

On some soils, the stand of lucerne may deteriorate very rapidly after the fourth or fifth year, unless it receives proper attention. It is naturally a strong grower and will hold its own if it has a fair chance. Where, for any reason, plants have been killed, seed should be sown as soon as possible.

Lucerne should never be grown in an orchard, for the roots go deeper than those of the fruit trees, and seriously retard, if they do not altogether destroy, the growth of the trees. The trees, however, may be planted on ground which has grown lucerne, for, through the action of the deep roots of the plant, mineral fertilizers are brought near the surface, the subsoil is made porous, and the dead and decaying roots furnish organic food in the best form for rapid absorption by the roots of the trees.

Lucerne as a Fodder.

When cut before it becomes too woody, there are few plants that are equal to lucerne in nutritive value. It makes an excellent hog pasture, but the plants must not be allowed to stand until they become hard and woody. The most nutritious fodder will be obtained by cutting off the plants every time they reach the blossoming stage. Sheep do well on it and produce a fine quality of wool. Dairymen who have used lucerne speak very highly of it as a cheap food for milk production. Bulletin No. 80 of the Geneva Experiment Station, New York, gives results of some feeding experiments in which lucerne and other forage plants were used in the feeding of milch cows. It was found in a great number of cases that where lucerne was substituted for some other food, or the amount of lucerne in the ration was increased, there followed a decrease in the cost of the milk. According to English* authorities, the feeding of lucerne to milch cows produced "milk that was not only rich in solids, but contained a large proportion of butter fat—the butter being of a brilliant yellow color, of exceedingly firm texture, even during the hot weather, and containing a most aromatic flavor."

It must not be forgotten, however, that lucerne, as a food for stock, deteriorates very rapidly after a certain stage of maturity has been reached. If allowed to stand until the blossom has fallen, a great many of the leaves will have dropped off, leaving the stalks comparatively bare. The woody part will have increased rapidly and the protein or flesh producing will have decreased; consequently the digestibility will have decreased, and possibly to such an extent that it will be unsafe to feed it in large quantities to any animal. During our digestion experiments, we fed three sheep for four weeks entirely on lucerne hay that was made after the plants had reached full blossom; and, at the end of the fourth week one of the animals was taken sick with impaction of the third stomach, caused, no doubt, by the indigestible nature of the food eaten. With proper treatment, it quickly recovered and, with the other two sheep, fed for four weeks longer on earlier cuttings of lucerne, without any further trouble. Some ripened lucerne has been fed by the farm department with serious results. In one case a valuable cow died of stoppage of the bowels; a post mortem examination showed that all passage had been stopped by a ball of indigestible fibre, which was supposed to have formed from the lucerne eaten. Although we have not had sufficient experimental evidence to prove it conclusively, it would seem as though there was great danger in feeding in large quantities lucerne hay that has been made from the plant in advanced stages of maturity. For this reason some have objected to its use altogether; but this is an extreme position to take; for, when cut in the earlier stages of its growth, lucerne has been found to be as digestible as either red clover or timothy.

Soiling Crop.

As a soiling crop, it is unsurpassed; it is one of the earliest crops, if not the earliest, in the spring, and by judicious arrangement may be used throughout the whole season. For soiling purposes, it may be cut before

*Royal Agricultural Society Report. Vol. 23, 1887.

blossoming; and as the sooner it is cut, the sooner another crop will follow, it is better not to wait for the full growth of the plant before commencing to use it. By beginning early and cutting about one thirty-fifth of the plot each day, so as to go over it every five weeks, a lucerne field will afford a constant cut from the latter part of May until October, since by the end of each five weeks the portion first cut will be ready with another crop. This is one of the best uses that can be made of lucerne; and, where at all possible, it will be found very profitable to have at least a small plot of it near the farm buildings for supplementary feeding, as all kinds of stock are fond of it. While all fodders deteriorate towards maturity, this is especially true of lucerne. This was clearly brought out by W. L. Summerby, one of the '98 graduating class of this college, who worked out an interesting thesis on "The Nitrogen of Lucerne." For analysis a cutting was made each week from the time the plant was six inches high until the blossom had fallen. The following is an extract from one of Mr. Summerby's tables:

PROTEIDS OF LUCERNE.

Time of Cutting.			Per cent. of Crude Protein.
1st	Cutting;	6 inches high	25.33
2nd	"	buds forming	23.24
3rd	"	first flowers	18.80
4th	"	full bloom	15.65
5th	"	blossom falling	14.23

The above shows clearly that as the plant matures, the amount of crude protein decreases, and, therefore, the nutritive value of the plant decreases. The earlier the plant is cut, the richer the food it makes. When we want the maximum amount of digestible matter per acre, other points have to be considered in determining at what stage of maturity the plant should be cut. This point will be discussed later.

As a Hay Crop.

Owing to the large amount of water in green lucerne and to the thickness of the stem, it is somewhat difficult to cure as hay. This is especially true of the first crop, which, besides containing a higher percentage of water than the succeeding ones, is usually ready for cutting while the ground is still damp from the spring rains, and before good hay weather has set in. As is the case with clovers, the leaves of lucerne break off very readily when dry; and, as these are the most nutritious part of the plant, there is likely to be considerable loss. The curing should, therefore, be done in the cock as much as possible; and, so far as practicable, the raking and handling should be done while the hay is a little "tough." The loss of the leaves will thus be reduced to a minimum. It would be impossible to give detailed directions for the curing of the hay, because conditions and weather vary so much in different parts of the province and different seasons. Much care and time are necessary to make good hay, and experience and good judgment are required.

Composition of Lucerne as Affected by the Stage of Maturity.

(a) *Plan of Experiment.*—A great diversity of opinion prevails among growers as to the stage of maturity at which lucerne should be cut to obtain the largest amount of digestible matter. To solve this question, we undertook a study of the composition and digestibility of the plant as affected by maturity. For this purpose, last year we cut the second crop of lucerne for the season at three different degrees of ripeness. The first cutting was made when the buds were well formed; the second, nearly two weeks later, when the blossoms were about one-third out; and the third, nearly another two weeks later, when the plant had passed the full blooming stage. This year we have cut both the first and second crops as nearly as possible at the same three stages of maturity. The crop, immediately after being cut, was weighed, then spread back on the ground, and cured in the usual way. The cured hay was again weighed and a sample taken for chemical analysis, the rest being used for the digestion experimental work. The three cuttings of each crop of this year were made from the same plot, which was one-tenth of an acre in size. Each cutting, therefore, was made from one-thirtieth of an acre. Lucerne from the same plot was used for the work done last year; but the cuttings were from a smaller area. The plot was situated on a hill-side, the soil of which was a gravelly loam with a clay sub-soil, and was seeded on the twelfth of May, 1894.

(b) *Result of Experiment.*—The following table gives the weight of the various cuttings calculated to the yield per acre:

Yield per acre in Green State and as Hay, and figured to Dry Matter.

	Green State.	As Hay.	Dry Matter.
Second crop, 1897.	lbs.	lbs.	lbs.
1st cutting; buds formed	17,100	3,761	3,197
2nd " blossom one-third out	15,400	4,493	3,819
3rd " a little past full bloom	11,500	3,902	3,317
First crop, 1898.			
1st cutting; buds formed	18,000	3,582	3,045
2nd " blossom one-third out	19,050	5,001	4,251
3rd " a little past full bloom	17,550	4,581	3,894
Second crop, 1898.			
1st cutting; buds formed	7,125	2,234	1,899
2nd " blossom one-third out	9,090	2,947	2,505
3rd " a little past full bloom	8,040	2,604	2,214

Very little rain fell during the growing period of the second crop of 1898, which will, no doubt, account for the much smaller yield than that obtained from the second crop of 1897. In every case but one, the largest yield in

green state, as hay, and as dry matter, was obtained from the second cutting, which, it will be noticed, was made when the plants were about one-third in blossom. It is quite possible that the weight of the crop would have increased for a few days longer; but it is evident that by the time the plant reaches full bloom or a little beyond, there is a marked decrease, which can be at least partially accounted for by the large number of leaves which had fallen off previous to the third cutting. Not only was the yield less in the third cutting, but the percentages of the most valuable food constituents had also decreased. This is shown in the following table:

PERCENTAGE COMPOSITION OF LUCERNE HARVESTED AT DIFFERENT DATES.

Calculated to water-free substances.*

—	Ash.	Crude Protein.	Crude Fibre.	Nitrogen-free Extract.	Crude Fat.	Amides.
Second crop, 1897.						
1st cutting; buds formed	8.54	20.12	28.47	37.88	4.99	3.73
2nd " blossom one-third out	7.09	15.54	31.57	42.90	2.89	4.52
3rd " a little past full bloom	6.23	13.79	40.46	37.54	1.99	2.88
First crop, 1898.						
1st cutting; buds formed	9.73	20.45	29.98	35.90	3.93	4.94
2nd " blossom one-third out	6.92	14.72	31.16	40.84	4.36	3.59
3rd " a little past full bloom	7.12	13.59	36.75	39.44	3.15	3.53
Second crop, 1898.						
1st cutting; buds formed	7.52	16.77	26.10	45.84	3.77	4.39
2nd " blossom one-third out	7.73	16.32	31.46	41.21	3.28	4.62
3rd " a little past full bloom	7.68	14.30	35.81	39.52	2.69	3.56
Averages of above.						
1st cutting	8.59	19.11	28.18	38.89	4.23	4.35
2nd cutting	7.24	15.52	32.06	41.67	3.51	4.24
3rd cutting	7 01	13.89	37.67	38.82	2.61	3.32
Averages of some American analysis of 1st and 2nd crops cut at similar stages of maturity.						
Buds formed	11.63	18.46	27.56	39.36	3.06	4.09
Medium bloom	9.60	15.44	33.58	39 08	2.40	2.23
Full bloom	8.35	13.12	37.64	39.36	1.94	1.86

* Fuller table of analysis will be found in the Chemical Department of the Ontario Agricultural College Report for 1898.

(c) *Explanation of terms.—Ash* is the part of the fodder which remains unconsumed by burning to whiteness at the lowest possible red heat. It is essential to the formation of bone. *Crude protein* is the muscle formers collectively, which includes both the albuminoids and amides. As protein is the most expensive part of a cattle food, a large amount of it in a fodder it

desirable. *Amides* appear to be an imature form of albuminoids and are not, capable of performing all the functions of the latter. As a plant matures, they are converted into albuminoids. *Crude Fat* is that part which is soluble in ether, and consists of a mixture of oils, wax, coloring matters, etc. Linseed oil is a common example. *Crude Fibre* is the woody portion of a fodder. It is the part that is most indigestible and therefore of the least value. *Nitrogen Free-Extract* is a mixture of substances commonly called carbohydrates. Starch and sugar are good examples.

Need of Determining the Digestibility.

It will be noticed that there is a marked similarity in the composition of the various cuttings of the different crops. The average composition of these cuttings will be found in the table; also, the averages of some American analysis of first and second crops which had been cut at different stages of maturity very similar to our own. It is interesting to note the similarity in composition of these two sets of averages. The table shows clearly that the per cent. of crude protein decreases, and that the crude fibre increases very rapidly. Since the other constituents are fairly constant in composition, the decrease and increase of the protein and fibre respectively affect to a very large extent the value of a fodder. As a plant matures, then, its most valuable constituent (protein) is decreasing in percentage while the most worthless part (crude fibre) is increasing very rapidly. This naturally leads to the conclusion that the earlier a crop is cut, the better it is for use as a fodder. It must not be forgotten, however, that up to a certain stage in the growth of a plant it increases in weight and consequently, while the percentage of crude protein decreases, the absolute amount may increase; also, that, as maturity advances, the protein becomes more valuable, as the amount of amides decreases. At the same time, crude fibre is increasing both relatively and absolutely. This is shown very clearly in the following table:

Table Showing the Increase or Decrease in the Amounts of Crude Protein and Crude Fibre.

Second crop 1897	Pounds of dry matter per acre.	Per cent. of crude protein.	Absolute amount of crude protein.	Per cent. of crude fibre.	Absolute amount of crude fibre.
First cutting	3,197	20.12	643.2	28.47	910.2
Second cutting	3,819	15.54	593.5	31.57	1,205.6
Third cutting	3,317	13.79	457.4	40.46	1,342.1
First crop 1898					
First cutting	3,045	20.45	622.7	29 98	912.9
Second cutting	4,251	14.72	625.7	33.16	1,409.6
Third cutting	3,894	13.59	529.2	36.75	1,431.4
Second crop 1898					
First cutting	1,899	16.77	318.5	26.10	495.6
Second cutting	2,505	16.32	409.5	31.46	788.1
Third cutting	2,214	14.30	236.6	35.81	792.8

It will be noticed that in two cases the absolute amount of crude protein increases with the second cutting and that in one case it decreases slightly, but that in every instance there is a decrease with the third cutting. The absolute amount of crude fibre increases with each successive cutting, although the total dry matter shows a marked decrease in the third cutting. It is evident from the above figures that the second cutting of each crop yielded the largest amount of dry matter and that here too, in two cases out of three, we obtained the largest amount of *crude protein*. But the crude fibre has increased so rapidly that in order to decide whether the crop has actually increased in food value or not, it is necessary to determine the digestibility of the constituents of the various cuttings; for it is only the part of the food which is digested that has any nutritive value.

Digestibility of Lucerne as Affected by the Stage of Maturity.

While the determination of the digestibility of the constituents of a fodder by an animal may seem to be comparatively simple, it is surrounded by many difficulties, which make the work tedious and tend to make the results somewhat uncertain. Consequently the work requires to be done a number of times before anything like reliable results can be obtained. We have now made in all seven tests with each of the three different cuttings.

Differences in age, breed and species of ruminants make comparatively slight differences in the proportions they digest from any given material. The seventh annual report of the Storr's Agricultural Experiment Station, Connecticut, has the following: "The results of digestion experiments in Germany warrant the following general conclusions upon the influence of species, breed, etc., upon digestibility of feeding stuffs.

a. Influence of kind of Animal.—All ruminants, such as cows, oxen, sheep and goats, seem to digest practically the same amount of protein, fat, nitrogen-free extract and fibre from the same kind of food. In general, horses digest less of the food constituents than do ruminants. This is especially true of the fibre and fat in the hays and grasses.

b. Influence of Breed.—The influence of breed upon digestibility has been studied with sheep, but no difference due to breed have been found. In general, it is probably true that different breeds of animals of the same species digest practically the same amounts of nutrients of the same foods.

c. Influence of Individual.—Individual differences have always been observed. The variation is quite wide; and, on this account, the results from the influences of kinds and breeds of animals are somewhat obscured, variations in the amounts digested by different individual animals of the same species and breed being wider than most variations in different species.

d. Influence of Age.—The few experiments conducted (principally with sheep) indicate very little difference, if any, due to age.

From the above it will be seen that the digestibility of a fodder by a sheep can be taken as a tolerably correct measure of its digestibility by a cow or steer. In our work, sheep have been used, because they are much more easily experimented with than larger animals.

Last year but one sheep was fed on each of the cuttings of lucerne; this year the experiment was made in triplicate, with three shearling wethers that followed through in succession the three different cuttings of each crop. The

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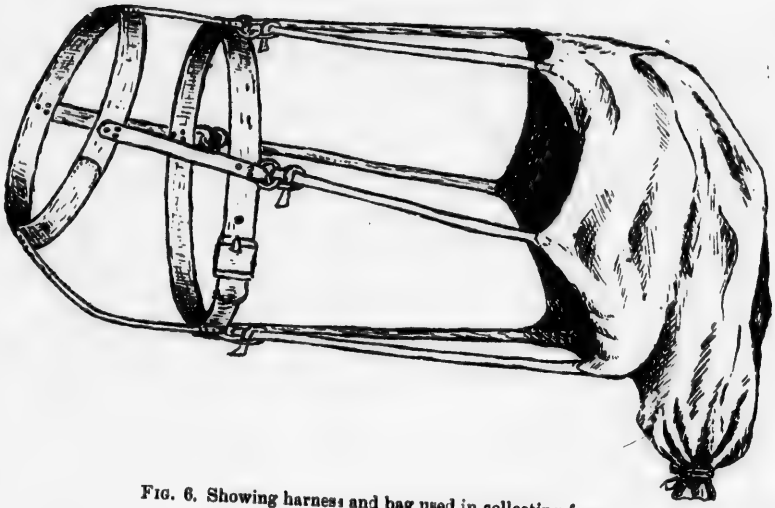

FIG. 6. Showing harness and bag used in collecting fæces.

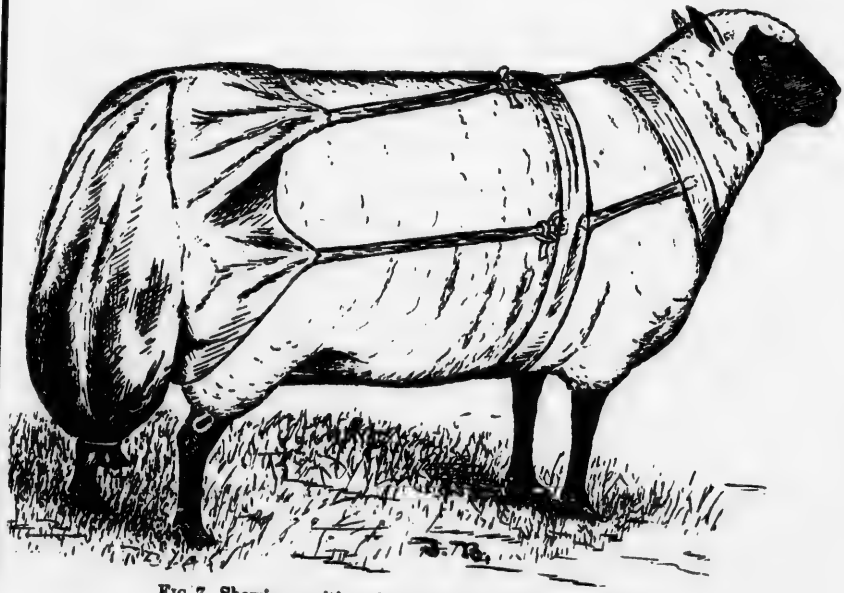

FIG 7. Showing position of the harness and bag on the sheep.

last cuttings of the two crops were purposely fed one after the other . see what effect they would have upon the digestive system of the animals, with the result that was previously mentioned.

e. Plan of Experiments.—A digestion experiment is usually conducted as follows: Healthy animals in the prime of life are fed a weighed amount of food of known composition, and in such a way as to prevent any possible waste. The undigested residues, which forms the solid excrement of the animal, is received directly into an appropriate bag attached to the animal. The excrement is dried, weighed and a representative sample ground and analysed. From the weight of the fodder fed and its percentage composition the weight of each constituent fed can be calculated. In like manner, from the weight of the dried excrement and its percentage composition, the weight of each constituent in the excrement can be determined. The difference between these two gives the amount of each nutrient which has been digested and resorbed during the passage of the food through the alimentary canal. The urine, containing solid bodies representing the waste of the animal organism, does not require to be analysed for the simple control of the digestive activities outlined above.

In this year's work each animal was placed in a pen which was about four feet square. The manger was arranged on the outside of the pen, with stanchions on the inside in which the animal's head was placed while feeding, thus effectually preventing any loss of food by scattering. No more of the fodder was fed than the animal would eat up without a particle of waste. A rubber-lined bag for collecting the fæces was attached to the animal by means of a suitable harness.

Each experiment lasted thirteen days and was divided into two parts. The first seven days were given to preliminary feeding, so that all traces of previous food might be removed from the system; the next six days formed the experiment proper, during which the solid excrement was carefully collected, being removed from the bags twice a day and placed on the drying pan. The results of this work will be found in the following table, which gives the number of pounds of each constituent digested, for every 100 pounds fed. For example: From 100 lbs. of protein fed 73.4 lbs. were digested in the first cutting, 72.8 in the second, and 64.4 in the third. These figures are what are known as digestion co-efficients, or the percentage digestibility of the constituents of the fodder. Each of the results in the table represents the average of seven digestion experiments; one of which was conducted with the second crop of lucerne in 1897, three with the first crop of lucerne in 1898, and three with the second crop of 1898.

f. Results of Experiment.—Digestion co-efficients, or the number of pounds digested out of every 100 lbs. of each constituent fed.

AVERAGE OF THE SEVERAL CUTTINGS.

——	Dry Matter.	Crude Protein.	Crude Fat.	Nitrogen free Extract.	Crude Fibre.
First cutting	58.6	73.4	48.8	71.8	30.1
Second cutting	56.2	72.8	50.4	70.1	37.7
Third cutting	51.3	64.4	44.1	64.0	37.1

From the above figures, it will be noticed that there is a gradual decrease in the digestibility of the hay as the growth advances. The deterioration appears to be more rapid during the period between the second and third cutting than during that between the first and second; or, in other words, there is a more rapid decrease in digestibility after the early blossoming stage than previous to that. Apparently the younger the plant, the richer it is in valuable constituents and the more digestible are these constituents. But, as has been pointed out, as the plant matures the absolute amount of these constituents increases. Therefore, when a crop is cut for hay, the object should be to cut at such a stage of maturity that the largest possible amount of the valuable constituents can be got without too great a decrease in digestibility. It has been shown that in every case the largest yield per acre of dry matter was obtained at the time of second cutting, or when the plants were about one-third in blossom. It has also been shown that after this period there is a more rapid decrease in digestibility. Hence it would appear that this is about the time when there is the largest amount of digestible nutrients present. This is borne out by the table given below.

Table showing the amount of digestible matter, calculated to the yield per acre, of the several cuttings of the different crops:

	Dry Matter. Lbs.	Digestion Co-efficient.	Digestible Matter. Lbs.
Second crop, 1897:			
First cutting, buds formed	3,197	58.6	1,873
Second cutting, blossom one-third out	3,819	56.2	2,146
Third cutting, a little past full bloom	3,317	51.3	1,701
First crop, 1898:			
First cutting, buds formed	3,045	58.6	1,784
Second cutting, blossom one-third out	4,...1	56 2	2,389
Third cutting, a little past full bloom	3,804	51.3	1,997
Second crop, 1898:			
First cutting, buds formed	1,899	58.6	1,112
Second cutting, blossom one-third out	2,505	56.2	1,407
Third cutting, a little past full bloom	2,214	51.3	1,135

The above figures show clearly that in our work the largest amount of digestible matter was obtained at the time of the second cutting, or when the growing crop was about one-third in blossom. As the different cuttings were made two weeks apart, it is possible that a larger amount of digestible matter would have been obtained a little earlier or a little later than the period mentioned. All that we can say is that according to the results of our work the crop should be cut when *about* one-third in blossom.

There is a marked dec...e in the digestible matter in the two weeks between the second and third cuttings. Taking an average of the three different crops, we find that this decrease amounts to 18.8 per cent, or very nearly one-fifth, of the digestible matter of the second cutting. Because of this rapid decrease in food value, also because of the rapidity with which the new crop comes on when the old one is removed, and because of the danger in allowing stock to eat the fodder when the plant becomes hard and woody, lucerne, whether in the pasture field or in the hay field, should not be allowed to stand later than the early blossoming stage.

Comparison of the Feeding Value of Lucerne, Red Clover, and Timothy.

It is interesting to compare the composition of lucerne hay with that of red clover and timothy, each crop being cut at the time when it apparently yields the maximum amount of digestible matter. The following table gives the percentage composition of the hays all figured to the same per cent of water, and the calculated amounts of the several constituents digested per ton of the hay fed.

Percentage Composition of Lucerne, Red Clover and Timothy Hay.

——	Water	Dry Matter	Protein	Fat	Nitrogen free Extract	Fibre	Ash
Lucerne	15.00	85.00	13.20	2.98	35.42	27.25	6.15
Red Clover	15.00	85.00	11.47	2.04	41.31	23.63	6.55
Timothy	15.00	85 00	6.03	1.70	45.22	23 31	3.72
Amounts digested per ton of hay fed.							
Lucerne	.....	955.40	193.19	30 04	496.58	205.46	.....
Red Clover	.....	974.95	141 03	29.38	587.42	209.36	.....
Timothy	.....	920 21	48.67	16.15	528.44	306.88	.....

According to the above figures, the clover hay contains the most digestible matter; but one ton of lucerne hay will contain about one-third more digestible protein than the same weight of clover hay, and nearly four times as much as a ton of timothy hay. In digestible nitrogen-free-extract and crude fibre it is lower than either of the other two.

R. Warrington, F. R S., in his book on "The Chemistry of the Farm." has the following on the comparative nutritive value of different foods: "The only basis on which the nutritive value of foods of different composition can be compared is in respect to their capacity for producing heat. The production of heat and mechanical work is the principal result which food accomplishes in the animal body; the capacity for producing heat is also intimately related to the capacity for producing fat. On the other hand, the amount of heat which any food is capable of producing stands in no relation to its power of increasing or renewing the nitrogenous tissues of the body. We may, however, safely assert that the amount of heat generated by the combustion of the digestible constituents of any food will be a fair guide to its nutritive value, when the diet of which it forms a part supplies a sufficient amount of digestible albunimoids, and this will be the case whenever foods are skillfully employed." If, then, these three fodders be compared upon the basis of their ability to produce heat or energy, they will bear the following relationship to one another :—Red Clover 100, Lucerne 91, and Timothy 86. If, however, allowance be made for the large amount of protein or flesh-producing material, in the lucerne, it will easily rank first as a food for young and growing stock. As has been stated, lucerne usually gives larger returns per acre than either red clover or timothy; and when this is considered along with the above facts regarding its nutritive value, it will be obvious that lucerne will be a valuable addition to our list of fodder crops.

Conclusions.

The foregoing results lead us to the following conclusions:

I. That the composition of lucerne is very similar to that of the clovers, both in food and in ash constituents.

II. That it is quite as digestible as red clover or timothy, when cut at the proper stage of maturity.

III. That, in our experiments, a much larger amount of digestible matter was obtained by cutting when the plants were about one-third in blossom than by cutting either two weeks earlier or two weeks later.

IV. That after the early blossoming stage the deterioration, both in percentage composition and in digestibility, is very rapid.

V. That, cut when about one-third in blossom, lucerne yields more digestible protein than either red clover or timothy.

VI. That there appears to be danger in feeding lucerne hay that has been made from the plant in advanced stages of maturity.

VII. That, notwithstanding the rapidity with which lucerne deteriorates after passing the early blossoming stage, the fact that, when properly saved, it yields a large amount of nutritious food, makes it a most desirable addition to our list of fodders.

APPENDIX.

At the time this bulletin was completed, the attention of the department was drawn to the fact that one farmer had just lost two valuable cows while pasturing on lucerne. Therefore, before allowing the bulletin to go to press, it was thought advisable to ascertain whether many other farmers had had similar experience. Accordingly a circular letter was prepared and sent to a number of farmers of our own province who have grown lucerne for some time, and to the Directors of a large number of American Experiment Stations, asking them what had been their experiences with lucerne as a pasture crop, as a soiling crop, and a hay crop. While every one who had used lucerne as a soiling crop reported very much in its favor, comparatively few had used it for hay or pasture, and, consequently could not report definitely under either of these heads. However, those who had had experience with lucerne as hay or pasture liked it very much, and reported no more trouble from pasturing it than from pasturing rank growing clover, provided the same precautions were taken.

Acknowledgements.

I desire gratefully to acknowledge the assistance received from the Experimental Department in the work of this bulletin. I also wish to state that, with the kind permission of Dr. W. P. Headden, A.M., Ph. D., chief chemist of the Colorado Agricultural Experiment Station, Figures 4 and 5 have been reproduced from bulletin No. 35 of that station.